Bulletin that the state of research into animal diseases in the tropics is at present lamentable.

Affirming that the facilities available in the British Empire in men, laboratory accommodation and equipment, are totally inadequate for the interests at stake, the Committee recommends the gradual creation of a cadre of research workers under an advisory organisation of scientific experts. On both scientific and political grounds it is desirable that no demarcation should be drawn between research work in the United Kingdom and that in other parts of the Empire.

The Committee is of opinion also that, should financial conditions become less stringent, assistance from State funds would be justified towards the creation of one strong Institute to serve the needs of the United Kingdom and possibly of the Empire. In such an institute, research would be made into the comparative aspects of disease as a whole, and workers in different branches of the subject—veterinary, medical, botanical—would be brought into association.

It is unfortunate that the Committee terminated its labours before the announcement of the gift to the Government by the Rockefeller Foundation of two million dollars for the creation of an Institute of Imperial Hygiene in London. It is understood that the Government has already accepted the responsibility of providing staff and maintenance of the Institute when established. Moreover, the "Shakespeare Memorial" site adjoining the area recently acquired for the University of London has been purchased.

This new development must enhance profoundly the position of London as the post-graduate centre of the Empire. It is understood that the Ministry of Health favours the integration of certain activities of various bodies like the London School of Tropical Medicine with those of the proposed Institute. In view of the enormous advantages which would ensue to the whole science of medicine from the intimate association of research workers in human and animal disease, it is to be hoped that serious efforts will be made to meet the legitimate aspirations of the veterinary profession for better facilities for research and post-graduate study in connection with the new Institute.

The General Theory of Relativity.

Space—Time—Matter. By Hermann Weyl. Translated from the German by Henry L. Brose. Pp. xi + 330. (London: Methuen and Co., Ltd., 1922.) 18*s*. net.

PROF. WEYL'S work is the standard treatise on the general theory of relativity. It is the most systematic and penetrating book on the subject; it is also by far the most difficult. The reader must not expect a helping hand over difficulties which are merely analytical; only the barest indication of intermediate steps is given in passing from one formula to another. The book is not suitable for a first introduction to the mathematical theory; but those who have already acquired some familiarity with the methods and manipulations required will find here a deeper insight and a more general view of the logical coherence of the theory than is possible in more elementary text-books. We think too that Weyl, more than other continental writers, approaches the outlook natural to an English student. The subtle distinctions between the Cambridge and the continental schools survive the revolution which has overtaken scientific thought. Even with Einstein we feel a need to anglicise his mode of thought, and this is still more necessary with some other German writers. But Weyl strikes just the right note for us; and though he is often too far ahead for us to follow, we pay him the (perhaps doubtful) compliment of claiming him as one of our own school of thought.

In some branches of applied mathematics the analytical methods have obviously no connection with the physical processes. The lunar theory is a notable instance; we cannot conceive that the processes by which the moon finds out where it ought to be are in any way analogous to those by which the computer solves the same problem. It is part of the charm of Einstein's theory that the mathematical methods correspond step by step with physical processes, so that not merely the result but also the form of the analysis is significant. The deeper our comprehension of the mathematical tool (the tensor calculus) the deeper will be our insight into the structure of the world. There are perhaps some who cherish the hope that ultimately simpler mathematical methods of treating these problems will be devised; but even if this hope were fulfilled the simplification would cost us dearly. If to our minds it seems simpler to solve the problems of Nature for her by methods other than those which she herself follows, that only accentuates our unfittedness to comprehend her processes. In Weyl's treatment the physical significance of each analytical operation is most strongly emphasised.

A distinctive feature of Weyl's work is his use of the conception of tensor-density in addition to tensor. These differ by a factor $\sqrt{g}$. In any region of the world, we can always choose a system of co-ordinates such that $\sqrt{g}=1$ everywhere; from the analytical point of view the factor is a useless complication which can be omitted without loss of generality, so that tensors and tensor-densities become equivalent. But this computational simplification plays havoc with the physical significance of the formulæ. Intensity-measures and quantity-measures become hopelessly confused. Weyl seems to have been the first to insist on keeping these distinct. He brings a meaning into formulæ which had previously appeared to be artificial combinations. The student who has with difficulty acquired some skill in operating with tensors has to learn in addition how to manipulate tensor-densities; but the results repay the extra labour.

Einstein has amalgamated for us geometry and mechanics. He has shown that if we have given an exact specification of the geometry of a region of space and time, that specification will also determine all the mechanical properties existing in the region—gravitational field, inertia, momentum, and stress. Einstein accepted for this purpose the geometry of Riemann. In 1918 Weyl showed that Riemannian geometry contains a limitation which makes it appear inappropriate to the description of a physical continuum from which all action at a distance is excluded. He generalised the geometry and so gave to the state of the world additional degrees of freedom. Actually four additional quantities had to be fixed in this more general specification of geometry; and he identified these with the four electromagnetic potentials. In this way the whole electrodynamic scheme is associated with the mechanical scheme, both being amalgamated with the geometry of the world. There is, however, an element of speculation in Weyl's unification which does not appear in Einstein's; the mechanical and geometrical properties of the gravitational field are aspects of the same phenomena; the electrical and geometrical properties of the electromagnetic field are not shown to be the same phenomena though they are supposed to originate in the same source.

Nearly half of Weyl's book is devoted to the development on a logical basis of a system of geometry. In this part we have to be content with laying a foundation, with scarcely a hint of the well-known phenomena of relativity which will follow. Knowing Weyl's great reputation as a pure mathematician, we felt some apprehension lest he should approach the study of space as though it were a matter of pure geometry. The fear was groundless. He recognises fully that he is dealing with a physical subject; and in his geometry space is recognised at the outset as a *form of phenomena* (p. 11), not a mere continuum of *n* dimensions. Among the most novel investigations is a justification of the Pythagorean metric (the quadratic formula for the interval) by an argument involving the theory of groups. The reasoning is difficult to follow.

As the changes made in successive German editions bear witness, Prof. Weyl is still developing his ideas. We think that near the end of the present edition he has reached conclusions which were not in his mind at the beginning. Four pages from the end, after some illuminating remarks on the two modes of transferring a quantity from place to place by "persistence" and by "adjustment" respectively, he decides that actual transference by clocks and measuring-rods corresponds to *adjustment*. Whilst this conclusion seems to be undoubtedly correct, the reader has scarcely been prepared for it, and indeed the existence of anything with respect to which adjustment can be made has only been demonstrated a few pages earlier. But the beginning of the book needs reconsidering in the light of this conclusion. How are we to reconcile the two following statements?

(1) The same object, remaining what it is, could equally well have been in some other place. The correspondence between the portions of space occupied in the two positions is called congruent transference (p. 11).

(2) A measuring-rod even in a statical field does not in general undergo a congruent transference (p. 308).

These are not the exact words, but I think that they convey the sense intended. It would seem to follow that a measuring-rod at another place and time is not precisely the thing it was. But it must be remembered that the statement (1) was enunciated as an axiom, which we were expected to accept as a matter of common experience; it is no place for metaphysical subtleties, which indeed Prof. Weyl is not likely to indulge in. There is, I believe, a direct contradiction between the initial premises (1) and the final conclusion (2) which can only be removed by revising our ideas as to the status of Weyl's ultra-Riemannian geometry. In spite of its specialised character the geometry of Riemann is the geometry of space and time ("the form of phenomena"), as Einstein assumed. Weyl's generalisation does not refer to actual space and time; but it gives us the needful mode of treatment in graphical guise of those fundamental relations which underlie the world of space and time and things.

Not until the last third of the book do we enter on the general theory of relativity. Then in a hundred pages we hasten through all the main results, including the re-formulation of mechanics to which Weyl has so largely contributed. De Sitter's and Einstein's rival views of a curved world are compared, and we gather that the author is not so hostile as most continental writers to the former. In either case, by noticing that $G^2\sqrt{g}$ (not $G\sqrt{g}$) is the fundamental scalar-density of zero dimensions, he is able to show that the cosmical curvature-term appears naturally and inevitably. Much of the more advanced theory depends on the Hamiltonian method of stationary variation of a volume-invariant. This is applied in two forms—

(1) Variations arising from changes of the reference-

frame vanish on account of the invariance. Equations so derived are mathematical identities which cannot be controverted.

(2) The vanishing of the variation for *all* small changes of the parameters is a possible form for a law of nature. Equations so derived rest on a particular hypothesis which challenges criticism.

We wish that the author had kept the results of these two applications distinct. We believe that most of the ascertained laws of physics are derivable by the first application, and the second is responsible for some additional results which cannot be tested and do not appear to us particularly probable.

The translator of such a book as this has our sincere sympathy. He has done a useful work which yet falls far short of complete success. There are many passages in the original which we have turned to again and again, and only very slowly grasped their meaning; others still defeat us. It was not to be expected that the translator would penetrate the thought behind them, and he has evidently given up the attempt to make his rendering convey any possible sense. We would not recommend any one to make a profound study of this work without having the German original at hand to consult when a difficulty is encountered. There are other mistakes harder to excuse. Weyl's treatment of space turns on the two conceptions of affine and metrical geometry, and it is impossible to proceed without mastering these. But the exposition of affine geometry on p. 18 refers continually to postulates I and II, and the reader will search in vain for any postulates so indicated. In the German edition a misprint of 1 for I is comparatively harmless; but in the English edition the further substitution of 2 for II extinguishes the reader's last hope of discovering what the argument refers to. On pp. 141-2, two axioms are printed as though they were headlines of the paragraphs following. Absurd mistranslations such as "mass of the earth" for "mass of the world" on p. 296 will probably not do much harm, though they shake our confidence. All the same, there is much good work in the translation, and those who are struggling to master Weyl's indispensable treatise will welcome the partial aid which it affords. A. S. E.

New Methods of Arctic Exploration.

The Friendly Arctic: The Story of Five Years in Polar Regions. By Vilhjahmar Stefansson. Pp. xxxi + 784 + plates. (London: Macmillan and Co., Ltd., 1921.) 30*s.* net.

NO such original and assertive explorer of the Arctic regions as Mr. Stefansson has appeared since Dr. Nansen startled the admirals by dispensing with a line of retreat. Mr. Stefansson's views are however, far more upsetting than those of Dr. Nansen, for he denies practically every theory and many reputed facts regarding the North Polar area, and contemns almost all the long-established methods of Arctic travel.

We cannot go on to Mr. Stefansson's vindication of his own powers as a pioneer without first deprecating his contemptuous tone with regard to arm-chair geographers and their views. Those harmless drudges do their best to follow the published narratives of explorers and to reconcile the contradictions between successive travellers' reports. If they say in their compilations that the Arctic Sea in its farther recesses is devoid of life it is because explorers have told them so, and if they dwell upon the hardships and dangers of Arctic explorations it is because earlier and less expert explorers did suffer and perish in the attempt to do, amid difficulty and pain, what proves easy and pleasant to Mr. Stefansson. We gladly acknowledge that Mr. Stefansson treats Peary as a great and successful explorer, and does full justice to McClintock's marvellous sledge journeys on the Franklin search; but he would have thought so much more of them if they had seen how easy it was to "live off the country"!

In pp. 30-32 much is made of the assumed ignorance on the part of Sir John Murray that sea-ice after long exposure on the surface of a floe can yield drinkable water. It seems to us that Sir John Murray probably controverted Mr. Stefansson's statement on this point not from ignorance but merely in order to test his character, for it was a common thing with Murray to see if a young man who knew something could be shaken in his confidence as to his own knowledge by the weight of an older man's authority. If Mr. Stefansson had wavered, as we are very sure he did not, Sir John Murray would have thought the less of him. As a matter of fact, we know that Murray was greatly impressed by the young Canadian's knowledge and fitness. With this book before them we are sure that the works of oceanographers and arm-chair geographers will henceforth be purged of some errors and fortified by many new facts; but the whole load of learning left by the old heroes of the North will not, on that account, be thrown into the sea like Stefansson's despised canned goods.

In 1913 the Canadian Government took over and financed an Arctic expedition which Mr. Stefansson had been organising in co-operation with the National Geographic Society of Washington and the American Museum of Natural History. These institutions withdrew their claims and so Stefansson's third Arctic expedition was purely Canadian. A great programme was prepared for work in two divisions, a northern in a